

# **CEV Seat Attenuation System**

## **System Design Tasks**

### **1 Crew Couch System**

#### **1.1 Overview**

The Apollo crew / couch restraint system was designed to support and restrain three crew members during all phases of the mission from launch to landing. The crew couch used supported the crew for launch, landing and in-flight operations, and was foldable and removable for EVA ingress/egress through side hatch access and for in-flight access under the seat and in other areas of the crew compartment. The couch and the seat attenuation system was designed to control the impact loads imposed on the crew during landing and to remain non-functional during all other flight phases.

Information available to the public on the design and operations relative to the Apollo couch and attenuation system will be provided to the class. (Apollo experience reports and others in the public domain will be made available to the class)

The design effort proposed here is to evaluate possible design approaches for any part or all of the following options: (1) the basic couch design layout in a CEV type crew compartment mockup/envelope to maximize its layout for all use operations; (2) Design of the couch to ensure compatibility with CEV emergency egress requirement of two minutes from couches out of the hatchway; (3) design approaches for designing the couch for foldability or being removable for on-orbit operations, where access to stowage and other items is required..

The new NASA CEV has adopted a similar philosophy as Apollo when it comes to crew impact protection. The CEV will mount six separate seats to a combined seat pallet or interconnected pallet inside the Crew Module. This pallet will be supported / suspended by a number of energy attenuating struts, the final number and configuration of which has yet to be determined. The class may work with another class project, if approved, related to the couch attenuation system.( The current NASA / Prime Contractor approach is energy absorbing struts).

The Apollo couch design is available for review, but I would be most interested in new, novel and potentially “off the wall” concepts to achieve the same goal.

Basic internal dimension of the CEV crew compartment will be provided and NASA mockup(s) will be arranged to be shown to class initially at the start of the project and later if necessary, and worked out with NASA-JSC, SF Division

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### **1.2 Statement of Problem**

You are the Seat Subsystem Manager. You must begin to develop the requirements for a seat system within the Crew Module and oversee the Prime Contractor's design efforts. You need to develop design approaches as outlined in above options, or provide inputs to currently defined seat layout or design, as you will be provided. You are not directly responsible for detailed design, but will develop approaches, recommended design requirements for the couches, in total, or some aspects of them as chosen, and address areas of design or develop design approaches needed by your class monitor, working with NASA-JSC subsystems manager. Your project may involve work with the other class project on attenuation of their approaches. Also assume that the seats themselves are being designed by another SSM or the other project team and that you can get him to agree to whatever interfaces you need. The vehicle is very tight on both mass and space, so smaller and lighter is preferable, but design flexibility for operational tasks and crew protection is the most important criteria.

### **1.3 Questions**

What are your overall plans to design this system? Provide a roadmap for system development.

What information are you missing? Do you know what you don't know? Who do you need to talk with to get that information?

Define tasks or efforts which need to be done in the design or interface areas, but in which you do not have the resources to do, but should be done.

Who are the stakeholders in this design?

What are the design requirements for your couch system? Develop and show a preliminary design concept(s) or design options, as selected..

What testing is required on the component level? What testing is required at the subsystem level?

What are your hardware interfaces? Which of those do you think you would have control over and which might provide "fixed" inputs?

Describe the phases of the program, beginning with conceptual design and ending at hardware delivery.

What are the biggest risks? What keeps you up at night?

What are the technological challenges associated with your approach? How would you overcome / mitigate them? How much will they cost (money and schedule)?

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What other subsystems will you impact? How will you get them to cooperate and accept your design? How will you address their concerns?

How will you work with your Prime Contractor, if their opinion differs from your own?

Would you ride the vehicle yourself, knowing what you know about the seat and attenuation system?

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### **1.4 Design Parameters – Generic**

#### **1.4.1 Force Characteristics**

Assume the force generated for the struts supporting the couch shall have a rapid onset rate (on the order of 30,000 pounds per inch) to a pre-determined load point (in the 2,000 to 3,000 pound range) and then demonstrate an increasing force at rates on the order of 200 to 300 pounds per inch after this onset through maximum force application at maximum stroke.

The force application shall be bidirectional and must be able to be utilized over multiple impact events.

#### **1.4.2 System Travel**

The total couch system shall be capable of  $\pm 8$  inches of travel in each of three mutually orthogonal axes simultaneously or different combinations of stroking, with a limit of the 8 inches.

#### **1.4.3 Mass**

Estimate the mass required for your design approaches. Mass minimization is a primary goal.

#### **1.4.4 Impulse**

TBD, to be worked out later. Apollo couch may be used as an assumption until this is better determined and provided.

#### **1.4.5 Usable Life**

The couch or related couch device shall not be re-used in flight use/service. However, the ability to pre-test and verify operation of the device after fabrication but before installation into the vehicle is critical.

#### **1.4.6 Cabin Access**

The couch design shall support access to controls and displays, vehicle systems required and access to stowage within the crew compartment..(scheduled use of JSC mockups is planned for your use in working this aspect)

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### **1.4.7 Couch Design for Astronaut Crew size/population**

Crew couch design will be compatible with selected crew astronaut sizing and population criteria, to be provided by NASA-JSC.

### **1.4.8 Couch design for Launch and Landing Loads**

The couch and struts will be designed to ensure safe launch and landing loads on astronauts. If project involves designing for this aspect, information available in the public domain will be provided to the class.

### **1.4.9 1.4.9 Couch Design for Emergency Egress**

The couch shall be designed to be compatible with suited emergency egress times of two minutes from initiation in the couch to egress from the side hatch.

### **1.4.10 Post-Operation Cabin Condition**

The couches shall not impact the cabin habitability after use/landing. Crew will need to live for up to 36 hours within the Crew Module after landing and will need access to all flight controls and most other systems during this period.( scheduled use of JSC mockups is planned for your use in working this aspect)

## **1.5 Design Parameters – Attenuating Struts**

### **1.5.1 Force Characteristics**

An idealized, normalized graph showing the desired strut characteristics is provided below:

NOTE: Please see end of this document for this graph(could not paste it in this location for unknown reason.

Typical values for the parameters shown are:

$K1 = 30,000 \text{ lb / inch}$

$F_{max} = 2,000 \text{ to } 3,000 \text{ lb}$

$K2 = 200 \text{ to } 300 \text{ lb / inch}$

### **1.5.2 Couch and Strut Stroke**

The stroke required is up to 8 inches in each direction of travel (tension and compression). The device may be activated multiple times in each direction, but the total

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stroke in that direction will not exceed the 8 inch requirement (i.e. – a strut may stroke 3 inches in compression during one load event and then 5 inches compression during a second load event).

The struts will not freely “reset”. They will require a force input (impact event) to return to their original position. They will demonstrate the appropriate force characteristic in either direction of travel at any point within their stroke range.

### **1.5.3 Mass**

The couch and struts will be minimized for mass.

### **1.5.4 Impulse**

The struts must be capable of responding to input forcing events on the order of 30 milliseconds (half-sine pulse duration). The struts shall stroke at a rate of at least 150 inches / second.

### **1.5.5 Accuracy / Overshoot**

The struts can not induce a load onset overshoot that exceeds 10% of the idealized force. During use, the struts must not deviate from idealized design by more than 5% at any point within the stroke length.

### **1.5.6 Useable Life**

The crew couch shall be useable from design, checkout, and verification of each flight unit through use in ground operations before flight and then through flight operations of one mission. This use shall include use during launch holds, mission aborts, and possible moving from one vehicle to another..

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